WHAT IS CLAIMED IS:

1. An apparatus for diagnosing faults in hot strip finishing rolling, comprising:

a Supervisory Control Computer (SCC) setting unit for applying preset target values, such as a target thickness, a target load, a roll speed and a roll gap;

an actually measured data collection unit for collecting actually measured data;

an exit side thickness gauge loaded-on determination unit for determining whether an exit side thickness gauge is loaded on, and starting diagnoses of the faults in the hot strip finishing rolling if the exit side thickness gauge is loaded on;

a part identification unit for identifying a front end part, body part and tail end part of a rolled sheet using thickness data;

an on-gauge ratio calculation unit for calculating on-gauge ratios on the front end part, the body part and the tail end part using the actually measured data collected by the actually measured data collection unit and the preset target values set in the SCC setting unit;

a primary fault determination unit for determining whether faults have occurred in the front end part, the body part and the tail end part using values output from the

actually measured data collection unit and the on-gauge ratio calculation unit;

a secondary fault determination unit for determining whether an operator intervention fault, a material fault, a facility fault and a control fault have occurred using values output from the actually measured data collection unit and the preset target values set in the SCC setting unit; and

a confidence rate evaluation unit for evaluating confidence rates of determination results of the secondary fault determination unit using the preset target values set in the SCC setting unit and the actually measured values.

2. The apparatus as set forth in claim 1, wherein the secondary fault determination unit comprises:

an operator intervention determination unit for determining whether an operator has intervened in a roll gap, a roll speed and spraying at a point when a thickness fault occurred;

a material fault determination unit for determining whether a material fault has occurred using an entrance side and exit side temperature deviation and an actually measured thickness;

a facility fault determination unit for determining whether roll eccentricity or a sensor fault has occurred; and

a control fault determination unit for determining

whether a control fault of a finishing mill has occurred.

3. The apparatus as set forth in claim 2, wherein the operator manipulation evaluation unit comprises:

a roll gap intervention determination unit for determining whether an amount of roll gap intervention is larger than the corresponding preset value set in the SCC setting unit if a sheet thickness deviation is larger than a consumer control tolerance, and determining whether an operator roll gap intervention fault has occurred by calculating an amount of thickness variation and comparing the amount of roll gap intervention with the amount of thickness variation if the amount of roll gap intervention is larger than the corresponding preset value;

a roll speed intervention determination unit for determining whether a roll speed intervention fault has occurred by calculating an inter-stand tension and comparing the calculated inter-stand tension with the preset tension value set in the SCC setting unit; and

a spraying intervention determination unit for calculating a sheet thickness using a stand load, comparing the calculated sheet thickness with the actually measured thickness, and determining that a spraying intervention fault has occurred if a deviation between the calculated sheet thickness with the actually measured thickness is smaller than

the preset critical value and a pattern of the thickness variation coincides with a pattern of an exit side temperature variation.

4. The apparatus as set forth in claim 2, wherein the material fault determination unit comprises:

an actually measured thickness FFT conversion unit for obtaining a sample rolling length using a maximal speed of each stand if a thickness deviation between the corresponding target value set in the SCC setting unit and the actually measured thickness value is larger than a consumer control tolerance, converting a thickness into constant length pitches based on the sample rolling length, and calculating a frequency of a period of a skid mark using the thickness data; and

a skid mark frequency intensity determination unit for determining whether a skid mark has occurred by calculating a frequency corresponding to each spectrum intensity using the converted value obtained from the actually measured thickness FFT conversion unit, searching for a frequency coinciding with a frequency of the skid mark and evaluating a spectrum intensity of the coinciding frequency.

5. The apparatus as set forth in claim 4, wherein the material fault determination unit comprises:

a sheet thickness sudden change determination unit for determining whether there is an interval where a sheet thickness is suddenly changed;

a carbon amount and target temperature determination unit for determining whether there is a possibility that a transformation fault occurs using the preset target temperature value set in the SCC setting unit and an amount of carbon if there is the interval where the sheet thickness is suddenly changed;

an actually measured temperature determination unit for determining whether an actually measured temperature satisfies a condition for occurrence of transformation if there is the possibility that the transformation fault occurs; and

a load/thickness correlation determination unit for determining whether there is a correlation between an actually measured load and a thickness by determining whether each stand coincides with a position of the sudden change of a sheet thickness if the actually measured temperature satisfies the condition for occurrence of transformation.

6. The apparatus as set forth in claim 2, wherein the control fault determination unit comprises:

a thickness deviation excess determination unit for determining whether a thickness deviation between the corresponding target value set in the SCC setting unit and the

actually measured thickness is larger than a consumer control tolerance;

an operator intervention determination unit for determining that the roll gap intervention fault has occurred if the thickness deviation is larger than the consumer control tolerance and a deviation between an amount of roll gap intervention of the operator in an i-th sample and an amount of roll gap intervention of the operator in an i+1-th sample is larger than a corresponding preset value set in the SCC setting unit;

an APC determination unit for determining that an APC fault have occurred if the thickness deviation is larger than the consumer control tolerance and a deviation between a preset roll gap value in the i-th sample and an actually measured roll gap value in the i-th sample converges into 0;

a rolling load deviation determination unit for determining whether a Finish Setup (FSU) deformation resistance expectation fault has occurred by determining whether there is a correlation between a load of the front end part and the sheet thickness if the thickness deviation is larger than the consumer control tolerance and a rolling load deviation is larger than a corresponding preset value; and

a temperature deviation determination unit for determining whether a FSU temperature expectation fault has occurred by determining whether there is a correlation between

the exit side temperature and the actually measured sheet thickness if the thickness deviation is larger than the consumer control tolerance and an actually measured exit side temperature is larger than a corresponding preset value.

7. The apparatus as set forth in claim 2, wherein the control fault determination unit comprises:

a minimal sheet thickness value calculation unit for calculating a minimal actually measured thickness value in a predetermined interval starting at a time when the thickness gauge is turned on by obtaining actually measured thickness values in the interval and determining whether the thickness deviation is larger than the corresponding preset value set in the SCC setting unit;

a fault determination thickness detection unit for detecting actually measured thickness values in a predetermined interval starting from a point where the minimal actually measured value is detected;

a maximal sheet thickness calculation unit for calculating a maximal actually measured thickness value in the interval; and

a front end part V-shaped fault determination unit for determining whether a front end part V-shaped sheet fault has occurred by determining whether a deviation between the minimal actually measured thickness value and the maximal

actually measured thickness value is larger than a preset value.

8. The apparatus as set forth in claim 7, wherein the control fault determination unit comprises:

an actually measured thickness/temperature correlation determination unit for determining whether there is a correlation between the actually measured thickness value and the actually measured exit side temperature if it is determined that the front end part V-shaped sheet thickness fault has occurred, and determining that a fault in cooling of a front end stand if there is the correlation;

a thickness/operator intervention correlation determination unit for determining whether the V-shaped sheet thickness fault and the roll gap intervention of the operator have the same polarity, and determining that a sheet thickness has been secured by the roll gap intervention of the operator;

a speed setting determination unit for determining that the thickness fault has occurred by the roll gap intervention of the operator if a deviation between the set roll speed value and the actually measured roll speed value converges into 0; and

an operator intervention determination unit for determining that an FSU speed setting fault has occurred if the deviation between the set roll speed value and the

actually measured roll speed value does not converge into 0 and is larger than a corresponding preset value set in the SCC setting unit, and determining whether the roll speed intervention of the operator has occurred by determining whether the actually measured thickness value and the tension have the same polarity.

9. The apparatus as set forth in claim 2, wherein the control fault determination unit comprises:

a temperature/thickness correlation calculation unit for calculating a correlation between a finishing rolling exit side temperature and an actually measured thickness value;

a temperature/thickness correlation evaluation unit for evaluating a magnitude of the correlation between the finishing rolling exit side temperature and the actually measured thickness value;

a rolling load frequency conversion unit for frequency converting the actually measured rolling load of the body part if the magnitude of the correlation between the finishing rolling exit side temperature and the actually measured thickness value is lower than a corresponding preset value set in the SCC setting unit;

a frequency determination unit for determining whether frequency components of monitor Automatic Gauge Control (AGC) and roll force AGC are detected after removing frequency

components regarding a skid mark and roll eccentricity that are generally and frequently involved in a frequency analysis of the actually measured finishing rolling thickness value from a value output from the rolling load frequency conversion unit; and

an AGC fault display unit for determining whether monitor AGC hunting or roll force AGC hunting has occurred if each of the frequencies is detected.

10. The apparatus as set forth in claim 9, wherein the control fault determination unit further comprises:

a thickness convergence period calculation unit for calculating a period that a thickness deviation between the actually measured thickness value and the corresponding target value takes to converge into a reference value;

a thickness convergence period determination unit for determining whether the convergence period is longer than a corresponding preset value set in the SCC setting unit; and

an AGC gain shortage display unit for determining that an AGC gain shortage has occurred if the convergence period is longer than the corresponding preset value and displaying the AGC gain shortage.

11. The apparatus as set forth in any of claims 6, 7 and 9, wherein the control fault determination unit further

comprises:

a thickness/width polarity determination unit for determining whether a width variation and a thickness variation have a same polarity at a point when a Down Coiler (DC) is turned on, and determining that necking has occurred if the two variations have the same polarity;

a temperature/thickness polarity determination unit for determining whether there is a correlation between a temperature variation and a thickness variation, and determining that a material and temperature fault has occurred if there is the correlation;

a thickness/gap occurrence point determination unit for determining whether an operator roll gap intervention fault has occurred by determining whether the roll gap intervention of the operator has occurred in a stand where the thickness variation occurred; and

a necking display unit for determining that necking has occurred without a width variation if the roll gap intervention has not occurred at the point when the thickness variation occurred.

12. The apparatus as set forth in claim 2, wherein the facility fault determination unit comprises:

a roll eccentricity fault diagnosis module for calculating upper and lower rotation frequencies of a backup

roll if a thickness deviation between the corresponding target value set in the SCC setting unit and the actually measured value is larger than the consumer control tolerance, FFT converting an actually measured exit side thickness value and calculating a frequency fa corresponding to each spectrum intensity using the FFT converted value, determining whether there is a point where a value n times the rotation frequency of the backup roll and the frequency fa corresponding to each spectrum intensity coincide with each other, determining whether the spectrum intensity corresponding to the frequency fa is larger than a coefficient set in the SCC setting unit, and displaying a stand where roll eccentricity has occurred; and

a thickness gauge fault diagnosis module for determining whether a thickness variation larger than a corresponding preset value has occurred in a period of single sampling if the thickness deviation is larger than the control tolerance and the exit side thickness deviation is continuously larger than β over a preset value γ set in the SCC setting unit, and displaying a thickness gauge fault if the thickness variation larger than the preset value has occurred.

13. The apparatus as set forth in claim 12, wherein the facility fault determination unit further comprises:

a temperature gauge fault diagnosis module for

determining that a temperature gauge has occurred if a temperature deviation has varied by a corresponding preset value set in the SCC setting unit or more and a load variation having occurred in a period of single sampling has varied by a corresponding preset value set in the SCC setting unit or more.

14. The apparatus as set forth in claim 1, wherein the confidence rate determination unit comprises:

a thickness deviation excess determination unit for determining whether a thickness deviation between the corresponding target value set in the SCC setting unit and the actually measured thickness value is larger than a consumer control tolerance;

a correlation calculation unit for calculating a correlation C1 between an amount of operator intervention and a tension variation, a correlation C2 between the thickness deviation and the tension variation, and a correlation C3 between the amount of operator intervention and the thickness deviation if the thickness deviation is larger than the consumer control tolerance;

a correlation polarity evaluation unit for evaluating polarities of the correlations C1, C2 and C3; and

a confidence rate calculating unit for determining the confidence rate to be 0 if at least one of the three

correlations has a (-) sign, and determining the final confidence rate of the operator roll speed intervention to be a mean of the three correlations if all the three correlations have an (+) sign.

15. The apparatus as set forth in claim 14, wherein the confidence rate determination unit further comprises:

a spraying correlation calculation unit for calculating a correlation D1 between the thickness deviation and the actually measured temperature, calculating a correlation D2 between the thickness deviation, calculated using the gauge meter equation in the stand where the operator spraying intervention has occurred, and the actually measured temperature, a correlation D3 between the actually measured thickness deviation and the thickness deviation calculated using the gauge meter equation, if the thickness deviation is larger than the consumer control tolerance; and

a spraying confidence rate calculation unit for determining the confidence rate to be 0 if at least one of the three correlations D1, D2 and D3 has a (-) sign, and determining the final confidence rate of the operator spraying intervention to be a mean of the three correlations D1, D2 and D3 if all the three correlations have an (+) sign.

16. The apparatus as set forth in claim 14 or 15, wherein

the correlation calculation unit or spraying correlation calculation unit calculates the correlation the following Equation 1 if it is assumed that two data for calculation of the correlation are f and g, respectively.

$$C1 = \frac{< f, g >}{\|f\| \cdot \|g\|} = \frac{\sum_{k=1}^{N} f_k g_k}{\sqrt{\sum_{k=1}^{N} f_k^2} \cdot \sqrt{\sum_{k=1}^{N} g_k^2}} \quad (1)$$

where C1 is the correlation, f and g are data vectors, <f, g> is the inner product of two vectors, and ‖ ‖ is a magnitude of a vector

17. The apparatus as set forth in claim 1, the confidence rate determination unit comprises:

a thickness deviation excess determination unit for determining whether a thickness deviation between the corresponding target value set in the SCC setting unit and the actually measured thickness is larger than a consumer control tolerance;

a stand mean spectrum intensity calculation unit for calculating a mean spectrum intensity of each stand using spectrum intensities of upper and lower backup rolls if the thickness deviation is larger than the consumer control

tolerance;

a spectrum intensity mean calculation unit for calculating a mean of spectrum intensities at frequencies other than the main frequencies of the upper and lower backup rolls;

a spectrum intensity comparison unit for calculating a deviation between the spectrum intensity at the main frequencies and the spectrum intensity at the frequencies other than the main frequencies; and

a confidence rate calculation unit for calculating the confidence rate of roll eccentricity using a deviation between the spectrum intensity obtained in the stand mean spectrum intensity calculation unit and the spectrum intensity obtained in the spectrum intensity mean calculation unit, if the spectrum intensity obtained in the stand mean spectrum intensity calculation unit is higher than the spectrum intensity obtained in the spectrum intensity mean calculation unit.

18. The apparatus as set forth in claim 1, wherein the confidence rate determination unit comprises:

a thickness deviation excess determination unit for determining whether a thickness deviation between the corresponding target value set in the SCC setting unit and the actually measured thickness is larger than a consumer control

tolerance;

a variation amount calculation unit for calculating an amount of thickness variation caused by a temperature fault, an amount of thickness variation caused by both intervention, and an amount of thickness variation caused by an FSU fault;

a polarity evaluation unit for evaluating the polarities of the three amounts of variation and an X-ray thickness deviation; and

a confidence rate calculation unit for determining a final confidence rate to be 0 if the polarities are different from each other, and determining each of the confidence rates to be in proportion to the X-ray thickness deviation.

19. The apparatus as set forth in claim 18, wherein the confidence rate calculation unit calculates the confidence rates using the following equations.

$$\Delta h_{xray\_top} = \Delta h^{X}_{fdt} + \Delta h^{X}_{both} + \Delta h^{X}_{fsu}$$

$$C_{fdt} = \frac{\Delta h^{X}_{fdt}}{\Delta h_{xray\_top}} \cdot 100[\%]$$

$$C_{both} = \frac{\Delta h^{X}_{both}}{\Delta h_{xray\_top}} \cdot 100[\%]$$

$$C_{fsu} = \frac{\Delta h^{X}_{fsu}}{\Delta h_{xray\_top}} \cdot 100[\%]$$

where C_{fdt} is the confidence rate of a temperature fault, C_{both} is confidence rate of both intervention, C_{fsu} is the

confidence rate of an FSU setting error, Δh_{fdt}^{X} is the amount of X-ray sheet thickness variation attributable to a temperature fault, Δh_{both}^{X} is the amount of X-ray sheet thickness variation attributable to both intervention, and Δh_{fsu}^{X} is the amount of X-ray sheet thickness variation attributable to an FSU setting error

20. A method of diagnosing faults in hot strip finishing rolling, comprising:

the first step of presetting a target thickness, a target load, a target roll speed and a target roll gap according to rolling conditions;

the second step of collecting actually measured data if an exit side thickness gauge is loaded on;

the third step of identifying a front end part, a tail end part and a body part using the actually measured data;

the fourth step of calculating on-gauge ratios in the front end part, the tail end part and the body part using the preset values of the first step and the actually measured data of the second step;

the fifth step of determining whether faults have occurred in the front end part, the tail end part and the body part using the preset value of the first step and the on-gauge

ratios of the fourth step;

the sixth step of determining whether an operator intervention fault, a material fault and a control fault have occurred at a point where a sheet thickness fault occurred; and

the seventh step of calculating a confidence rate of the control fault using the preset values of the first step and the actually measured data of the second step.

21. The method as set forth in claim 20, wherein the sixth step comprises the sub-steps of:

determining whether operator intervention has occurred in a roll gap, a roll speed and spraying;

determining whether a material fault has occurred using a deviation between the entrance and exit side temperatures and the actually measured thickness value;

determining whether a facility fault by determining whether roll eccentricity or a sensor fault has occurred; and

determining whether a control fault by determining whether examining FSU, AGC and a motor.

22. The method as set forth in claim 21, wherein the sub-step of determining whether the operator intervention has occurred comprises:

the first step of presetting a preset target values, such

as a target thickness, a target load, a target roll speed and a target roll gap according to rolling conditions;

the second step of determining whether an amount of roll gap intervention is larger than the corresponding preset value set in the SCC setting unit if a sheet thickness deviation is larger than a consumer control tolerance, and determining whether an operator roll gap intervention fault has occurred by calculating an amount of thickness variation and comparing the amount of roll gap intervention with the amount of thickness variation if the amount of roll gap intervention is larger than the corresponding preset value;

the third step of determining whether a roll speed intervention fault has occurred by calculating an inter-stand tension and comparing the calculated inter-stand tension with the preset tension value set in the SCC setting unit; and

the fourth step of calculating a sheet thickness using a stand load, comparing the calculated sheet thickness with the actually measured thickness, and determining that a spraying intervention fault has occurred if a deviation between the calculated sheet thickness with the actually measured thickness is smaller than the preset critical value and a pattern of the thickness variation coincides with a pattern of an exit side temperature variation.

23. The method as set forth in claim 22, wherein the sub-

step of determining whether the operator intervention has occurred further comprises the step of:

collecting actually measured data by measuring actually measured data, such as a thickness, an entrance side temperature, an exit side temperature, a rolling load and a roll gap of the rolled sheet.

24. The method as set forth in claim 21, wherein the sub-step of determining whether the material fault has occurred comprises:

the first step of presetting a preset target values, such as a target thickness, a target load, a target roll speed and a target roll gap according to rolling conditions;

the second step of obtaining a sample rolling length using a maximal speed of each stand if a thickness deviation between the corresponding target value set in the SCC setting unit and the actually measured thickness value is larger than a consumer control tolerance, converting a thickness into constant length pitches based on the sample rolling length, and calculating a frequency of a period of a skid mark using the thickness data; and

the third step of determining whether a skid mark has occurred by calculating a frequency corresponding to each spectrum intensity using the converted value obtained from the actually measured thickness FFT conversion unit, searching for

a frequency coinciding with a frequency of the skid mark and evaluating a spectrum intensity of the coinciding frequency.

25. The method as set forth in claim 24, wherein the sub-step of determining whether the material fault has occurred further comprises:

the fourth step of determining whether there is an interval where a sheet thickness is suddenly changed;

the fifth step of determining whether there is a possibility that a transformation fault occurs using the preset target temperature value set at the first step and an amount of carbon if, as a result of the determination at the fourth step, there is the interval where the sheet thickness is suddenly changed;

the sixth step of determining whether an actually measured temperature satisfies a condition for occurrence of transformation if, as a result of the determination at the fifth step, there is the possibility that the transformation fault occurs; and

the seventh step of determining whether there is a correlation between an actually measured load and a thickness by determining whether each stand coincides with a position of the sudden change of a sheet thickness if, as a result of the determination at the sixth step, the actually measured temperature satisfies the condition for occurrence of

transformation.

26. The method as set forth in claim 21, wherein the sub-step of determining whether the facility fault has occurred comprises:

the first step of presetting a preset target values, such as a target thickness, a target load, a target roll speed and a target roll gap according to rolling conditions;

the second step of calculating upper and lower rotation frequencies of a backup roll if a thickness deviation between the corresponding target value set in the first step and the actually measured value is larger than the consumer control tolerance, FFT converting an actually measured exit side thickness value and calculating a frequency fa corresponding to each spectrum intensity using the FFT converted value, and determining whether there is a point where a value n times the rotation frequency of the backup roll and the frequency fa corresponding to each spectrum intensity coincide with each other;

the third step of determining whether the spectrum intensity corresponding to the frequency fa is larger than a coefficient set in the first step, and displaying a stand where roll eccentricity has occurred; and

the fourth step of determining whether a thickness variation larger than a corresponding preset value has

occurred in a period of single sampling if the thickness deviation is larger than the control tolerance and the exit side thickness deviation is continuously larger than β over a preset value γ set in the SCC setting unit, and displaying a thickness gauge fault if the thickness variation larger than the preset value has occurred.

27. The method as set forth in claim 26, wherein the sub-step of determining whether the facility fault has occurred further comprises:

the fifth step of determining that a temperature gauge has occurred if a temperature deviation has varied by a corresponding preset value set in the first step or more and a load variation having occurred in a period of single sampling has varied by a corresponding preset value set in the SCC setting unit or more.